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FILE

MEMO TO : All Industrial Radiography Licensees

FROM : Kenneth W. Wangler
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RE : Operational Topic: "Managing a Sound Industrial Radiography Radiation Safety Program"

DATE : December 6, 2000

Enclosed is a copy of an article appearing in the November 2000 (Vol. 79, No. 5) edition of the Operational Radiation Safety Journal published by the Health Physics Society. The enclosed article entitled, "Managing a Sound Industrial Radiography Radiation Safety Program" provides basic information needed to ensure safety, security and control of the radiographic sources used in industrial radiographic operations.

It is expected that you will review this information for applicability to your licensed activities and consider actions, as appropriate, to ensure the safe and legal use of radioactive material in the State of North Dakota.

This notice is for your information only. No specific action nor written response is required. If you have any questions concerning this article, please contact the Radiation Control Program at 701.328.5188.

KWW/JMG:csc
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A well-executed radiation safety program can minimize the risk of mishaps and unacceptable exposure to radiation while using industrial radiography sources.

Managing a Sound Industrial Radiography Radiation Safety Program

René Michel and Stephen A. Simpson†*

Abstract: *This article was developed to provide new radiation safety officers with the basic information needed for ensuring safety, security, and control of industrial radiography sources and to discuss licensing requirements and other information pertaining to the management of radiation safety programs associated with these sources. Health Phys. 79(Supplement 2):S56–S60; 2000*

Key words: *operational topic; radiation protection; radiography; quality assurance*

INTRODUCTION

Industrial radiography (IR) is the process of using either gamma-emitting radionuclide sources or x-ray machines to examine in a non-destructive manner the integrity of materials or components to assure that they are safe to use (Briggs 1981). Radiography is a regular component of some manufacturing and non-destructive testing (NDT) operations. IR facilities include shipyards, foundries, bridge fabricators and pressure vessel (boilers and code tanks), bridge, diameter pipe, integrated circuit and tire manufacturers (LaMastra 1998). IR is typically performed in shielded radiographic installations (in which the exposure to people is controlled by limiting the access) and at field stations. In this process, the product to be tested is placed between a radiation source and a radiation sensitive film or a storage phosphor screen (Fig. 1).

Imperfections in the sample, such as air bubbles, cracks, or impurities allow more radiation to reach and expose the film or storage phosphor screen. After processing, these areas appear as darker spots on the developed film or storage phosphor screen.

IR cameras are very useful tools, but if not used properly they may involve significant risks for their users and the general public. Sources used in IR emit intense and penetrating radiation needed for studying thick metal samples. Typically, the best radiographs are produced by small but highly radioactive sources. If held in contact with the body, these sources can cause serious radiation exposures (sufficient to lead to radiation burns) in seconds. Most radiography accidents occur when safety and operating procedures are not followed such as inadvertently leaving the source out of the shielded camera, failing to perform a survey to ensure that the source has returned to its protective housing, or failing to lock the source in place after use (U.S. NRC 1982).

BASIC CAMERA OPERATION

A radiography camera (Fig. 2) is basically a shielded container with a radioactive source, most commonly ^{192}Ir or ^{60}Co, both gamma ray sources (Gardner and Ely 1967).

IR sources are small in size but highly radioactive. Typical activities range from 10 to 400 curies depending on their intended application. Using uranium as shielding material instead of lead reduces the camera's size and weight, thus improving its portability. IR cameras have various means for unshielding the source in order to make exposures. This allows the emitted gamma to expose radiation sensitive film. The

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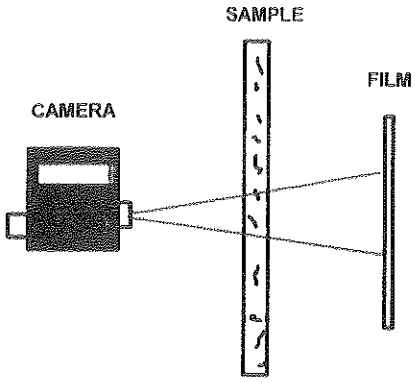

Figure 1. Diagram of a typical industrial radiography process.

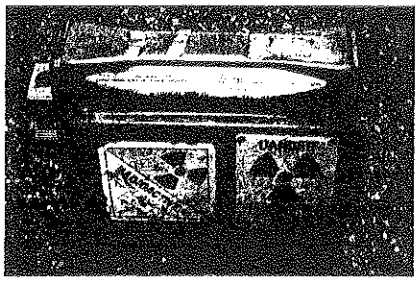

Figure 2. Picture of a typical portable IR camera.

following is a discussion of two mechanisms in which these devices operate.

Crank-out system

In this system, an s-tube passes through a lead or uranium shield in such a way that radiation does not leave the camera without passing through the shielding material. The source is exposed by pushing it out of the camera on the end of a drive cable through a guide tube (Fig. 3).

Beam-type system

In this system, the source is moved within the camera to an opening in the shielding. By turning a control knob, the source is rotated and placed in front of an unshielded opening. The radiation beam emerges from the opening though a thin protective cover (Fig. 4).

REGULATORY ASPECTS

Since the radioactive material found in IR cameras can be hazardous if not used properly, its possession and use is regulated. In the United States, the federal agency in charge of controlling radioactive material is the Nuclear Regulatory Agency (NRC). Agreement States are allowed to regulate such sources provided their regulations are as restrictive as the regulations set down by the NRC. Regulations enforced by the NRC are contained in Title 10 of the Code of Federal Regulations (CFR) Parts 2, 19, 20, 21, 30, 34, 40, 71, 150, 170 and 171 and in Title 49 CFR Parts 170 to 189 (U.S. NRC 1999). Each Agreement State writes its own set of regulations based on these regulations.

To possess and use these devices, organizations or individual users must obtain a radioactive material license. Typically both the NRC and Agreement States publish guidelines to help applicants in the licensing process. The NRC has published NUREG-1556, Vol. 2 (U.S. NRC 1997), designed to assist potential licensees in preparing IR applications.

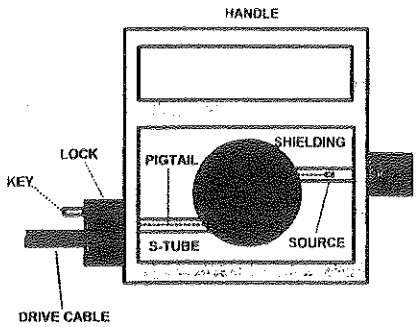

Figure 3. Diagram of a portable crank-out IR camera.

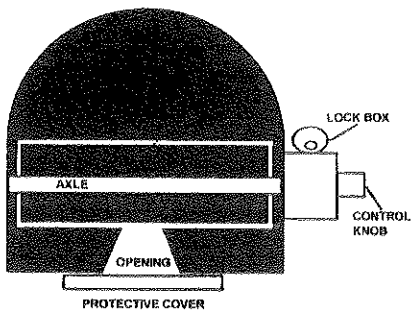

Figure 4. Diagram of a portable beam-type IR camera.

Regulations mandate compliance with some general requirements such as designating a person in the organization as the radiation safety officer (RSO) who, besides being the contact person for the regulatory agency, also ensures that these devices are properly used and maintained, personnel are adequately trained, devices are secure at all times, and required audit, calibration, inventory, and survey records are accurate and complete.

Regulators perform periodical inspections to ensure compliance with these requirements. RSOs should prepare for unannounced inspections by reviewing available guidance on the subject (Michel and Lopez 1998). Inspectors may spend many hours reviewing procedures, observing users during the operation of these devices, and interviewing personnel. The inspection length and scope depends mainly on the size and condition of the radiation safety program.

BASIC RADIATION PROTECTION TECHNIQUES

The ALARA principle is the fundamental tenant of radiation safety. Federal regulations require the implementation of personal protective measures in order to maintain both occupational and non-occupational doses "As Low As is Reasonably Achievable."

It is the responsibility of the radiographer to keep his occupational dose ALARA. This can be achieved by

1. Reducing the amount of time spent working in the vicinity of these devices. This can be accomplished by knowing the standard operations of these devices and understanding the scope of work to be performed;
2. Increasing the distance from cameras. This can be accomplished by standing away from them during exposures, using

longer sets of controls cables and laying them out straight, and keeping them as far as possible from the driver during transportation;
3. Using shielding. This can be accomplished by using dose reducing collimators or additional shielding when possible; and
4. Rigidly follow the protocols for the safe use of these devices.

LICENSING REQUIREMENTS

As discussed above, regulatory agencies publish guidelines on the licensing of IR sources. These guidelines describe the type and extent of information needed by the regulatory agency to evaluate an application to use these instruments. Depending on the nature of the use, the regulatory agency may impose additional requirements. These requirements are called license conditions. A small description of the typical IR regulatory requirements follows.

The implementation of an ALARA program

By law, licensees are required to implement reasonable measures to maintain occupational and non-occupational doses ALARA. Everybody in the organization including management, the RSO, and the industrial radiographer is subject to this requirement. Regulations usually require a formal (i.e., written) policy commitment. This ALARA document should encourage the application of this concept within the organization. It should include areas such as formal annual reviews of the radiation safety program and quarterly reviews of occupational exposures.

Proper instruction to workers

To be considered eligible for an RSO position an individual must have hands-on experience as a qualified radiographer and formal training in establishing and maintaining a radiation safety program. The level of experience and training required usually varies depending on the size and complexity of the operations. Radiographers should receive formal instruction in operating and emergency procedures, using exposure devices and associated equipment, as well as using survey instruments and other radiation detection devices. Recent changes in regulations require radiographers to be certified by a third party acceptable to the NRC and Agreement States. The only organization currently authorized to provide this certification is the American Society of Non-Destructive Testing (ASNT). Some regulatory agencies also require industrial radiographers to participate in annual refresher training sessions and to inspect their job performance at intervals not to exceed six months. The RSO must keep these training records on file for regulators to review during their compliance inspections. Licensees are usually required to provide proper hazard-awareness instruction to non-radiation workers, such as ancillary personnel, whose duties may require them to work in the vicinity of these devices (Michel and Kerns 1999).

Facilities and equipment

Licensees are required to use and store radiography sources only in approved locations (i.e., permanent installations or at field stations). Engineering and administrative controls must be in place to restrict unauthorized individuals from accessing these locations and to ensure that radiation levels in their surroundings do not exceed any regulatory limits. Permanent installations require high radiation area controls such as alarm devices, interlocks, emergency stops, and postings. The American National Standard Institute (ANSI) has published standards on radiological safety aspects for the design and construction of such facilities (ANSI 1992). Recent changes in regulations require all radiography at locations named on an NRC license to be within an enclosed facility. The NRC added the definition of "field station" to cover the need for radiography of very large objects that do not fit in an enclosed room. These field stations must be listed on the license. In the past, very large operations such as ship-repair yards treated these operations as temporary job sites and roped off the immediate area.

Source security

Licensees are required to prevent access to radioactive material by unauthorized individuals. Cameras used at field stations are considered secure if they are physically attended while in use or kept locked when not in use. While in storage, cameras must be locked in such a way that unauthorized personnel cannot gain access to them. The storage area must be posted with a radioactive material sign, and a survey must be performed to verify that radiation levels are below the applicable regulatory limits. Cameras can be locked in the trunk of a vehicle, hidden from view while in a locked van, or secured by lock and chain while in an open bed truck. It is not acceptable for cameras to be chained to a post or left unattended at the place of use while taking a break since the device would be accessible to unauthorized individuals. It is the responsibility of the RSO to implement measures to assure that cameras are secure at all times and the responsibility of the radiographers to observe them. Lack of source security is one of the most serious violations identified during compliance inspections.

Personnel monitoring

IR is traditionally the sector of the nuclear industry that generates the highest individual occupational doses to radiation workers. They are required to wear a combination of an approved direct-reading dosimeter (i.e., a pocket or electronic personal dosimeter), an alarm rate meter, and either a film badge or a TLD. At permanent radiography installations where other alarming devices are routinely used, wearing an alarm rate meter is optional. Radiation survey meters are to be calibrated at intervals not to exceed 6 mo and after repairs. Before using a survey meter, radiographers should perform a battery and calibration date check and verify the response of the instrument with a known source of radiation (i.e., the radiography camera). If any of these checks fail, the RSO should be informed immediately. Licensees occasionally receive notices of violation for not using monitoring devices as required. Most radiography accidents have occurred when radiographers failed to return the source to the fully shielded position and/or failed to perform an adequate radiation survey (Fig. 5).

Maintenance

Licensees are required to have procedures in place for inspecting and maintaining radiography cameras, source changers, associated equipment, transport and storage containers, and survey meters. Licensees are required to perform visual and operability checks on a daily basis before using IR equipment. Inspection and maintenance of radiographic equipment should be conducted at intervals not to exceed 3 mo to ensure that they are functioning properly. All routine maintenance work such as cleaning and lubrication of the drive cable mechanism should be based on the manufacturer's recommendations. The ALARA techniques (time, distance, and shielding) along with common sense should be applied while performing this type of work. Serious injuries occur every year when workers fail to properly maintain equipment or carry out routine monitoring procedures.

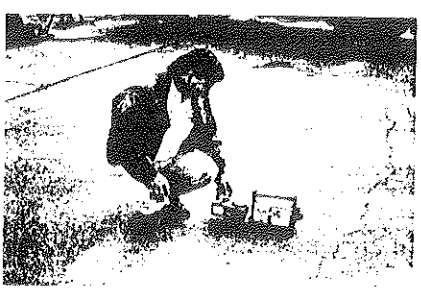

Figure 5. Most IR accidents can be avoided by properly surveying cameras before and after use.

Leak testing

Even though the radioactive material in radiography cameras is encapsulated in stainless steel, licensees are required to verify that radioactive sources are not leaking. Approved leak tests are to be performed in 6-mo intervals by a qualified individual. Leak test kits (i.e., cotton swabs or filter paper) are commercially available. Wipes should be kept separate to avoid cross contamination. While performing leak tests, it is important to identify each camera tested by recording the serial number, nuclide, and activity. Wipes should be taken from the most accessible area where contamination would accumulate if the sealed source were leaking. Leak test wipes should be analyzed using appropriate and calibrated counting equipment and by a licensed individual. Failing to properly perform and document wipe tests is a common problem found during compliance inspections.

Compliance with transportation requirements

Packaging and transportation of IR cameras must comply with the Department of Transportation (DOT) Regulations. These requirements include labeling containers appropriately (i.e., Radioactive White I, Yellow II or III), securing the device within the transportation vehicle, and completing shipping papers before transporting the licensed material. If the package being transported requires a Radioactive Yellow III label, placarding both sides, front, and back of the transportation vehicle with "radioactive" placards is required. Also required are emergency response information, inspection prior to shipment, and a properly completed bill of lading. The bill of lading must be in the transport vehicle and immediately accessible to the driver. This document includes the following information: the name of the shipper, a description of the shipment, an emergency response phone number, the shipper's certification, and the shipper's signature. The description of the shipment includes information such as the proper shipping name (the words Reportable Quantity or "RQ" must be added to this name), hazard class, identification number, type of package (i.e., usually B), name and activity of each nuclide, category of labeling, and transportation index (TI).

Operating and emergency procedures

A copy of approved operating and emergency procedures should be always readily available for radiographers to use. Operating procedures should address the following areas: The proper use of survey instrumentation and personal monitors and step-by-step information on how to operate, store, and transport radiography cameras. Careful planning is also needed for complex jobs such as working in a structure where there could be access to the controlled area at different levels. A fail-safe communication

system between radiographer and assistants prevents misunderstandings and helps in preventing accidental exposures due to poor communication. Recent changes in regulations require storage containers for radiography sources to automatically lock when the source is returned to the storage container after each exposure. Emergency procedures should address information on how to properly respond to emergencies, such as when the source fails to return to the shielded position or is involved in an accident. The RSO with the help of the radiographer should periodically review and improve emergency procedures. Serious injuries occur every year when workers fail to properly employ emergency procedures.

Inventory

Regulatory agencies typically require IR licensees to conduct an inventory of cameras possessed at intervals not to exceed 3 mo. Inventory records should include the nuclide and amount of material in each source, the manufacturer's name, model number and serial number of each camera, their storage location, the date of inventory, and the name of the individual performing the inventory review. The inventory record should be reviewed and signed by the RSO. Failing to properly perform and document inventories is one of the most common violations issued to IR licensees.

Disposal

Because of the nature of the radioactive material contained in these devices, the only methods of disposal are by transfer to an authorized recipient, such as a commercial firm authorized to receive radioactive waste or another licensee authorized to posses such material. Licensees must obtain prior consent from regulators if a transfer of radioactive material control occurs as a result of company mergers, buyouts, or majority stock transfers. This is to ensure continuity and regulatory compliance.

Audits

Most regulatory agencies require an annual audit of the radiation safety program to ensure that proper safety and operating procedures are being followed. These audits are more effective when they are performed unannounced in the field where cameras are normally used. Inspectors review records of these audits during their periodical visits. RSOs may perform these audits themselves or consider hiring a qualified consultant to perform them. A good alternative is to participate in a reciprocity program with another IR licensee (Michel and Eichner 1999). It is important to correct problems identified during audits in a timely manner. Regulators often do not cite licensees for violations that have been identified and properly corrected.

CONCLUSION

By following basic guidelines for radiation protection such as time, distance, shielding, security, and control of radiography cameras, the licensee can ensure the occupational and nonoccupational exposures from these devices are ALARA. Also, following licensing requirements and other information pertaining to the management of IR radiation safety programs, the licensee can ensure regulatory compliance.

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